Description

Positioning System for Racing Cars

The present invention relates to a positioning system for racecars, in particular for use at Formula 1 races.

Sports racing with various types of racecars has been known and popular for centuries. Its popularity has led to the ongoing development and application of special vehicles for different types of races, track preparation measures, driving techniques, etc. New developments aimed at enhancing safety, providing more information to the public, increasing car speed, etc, are constantly being made.

US 5,731,788 discloses a system and a method for checking position and managing racing sailboat positions and speeds, which involve the strategic placement of GPS receivers and transmitters in a buoy and a committee boat that mark the starting line of the boat race, as well as radio and GPS receivers on the sailboat. GPS and radio units are placed in a start buoy and a start vessel, and another GPS and radio receiver unit receives GPS signals from positioning satellites and radio signals from the start buoy and the committee boat. The information received from the race boat is processed to find the relative and absolute positions and speeds, and the estimated arrival time using the intersection of the current sailboat course with the starting line for display in a user-friendly race management device.

US 3,714,649 describes an example of a vehicle monitoring system using a fully automatic system to monitor car racing or the like. Each vehicle carries a transponder, which registers its own passing of a position event, for example crossing the starting-finish line, entering or leaving the grandstand area, etc., and transmits a characteristic signal to a receiver on the track shoulder next to the position event in a time-division multiplex method with the transponders of all other vehicles. A main transmitter

transmits a time-division synchronization signal to all vehicle transponders and every transponder is embodied to send a position event signal only for a predetermined time period of the synchronization signal. The receivers on the track shoulder feed a central control unit, which is also synchronized with the main transmitter, and enters the appearance of each vehicle's position event in real time. A clock and a computer are provided for determining the order, lap speeds, etc. from the entered data. The system for recognizing a position event is based on the principle that the vehicle's inductance crosses a variable magnetic field whose polarity defines the position of the respective event.

US 4,949,067 also describes a car racing status warning system which comprises a transmitter operated by a section monitor or another racing official, and a sufficient number of receiver units to allow each racecar to have a receiver unit. The transmitter sends an encoded signal that can be received along the entire track, and corresponds to a red, yellow or green flag. The receiver units, which are self-contained and include a built-in power supply, receive and decode the signal and switch on green, yellow or red lights. The system offers the race participants an essentially instant notification of danger on the track.

The object of the invention is to provide a positioning system for racecars offering expanded functions, simplified use and enhanced safety over the previous prior art. Additional advantages of the invention will be described in greater detail below.

This object is accomplished by the features of Claim 1 and Claim 2. Preferred embodiments of the invention are defined in the dependent claims.

Basically, according to a first embodiment, the invention consists of a vehicle-information device that is housed in the racecar and comprises a positioning device for collecting and outputting positioning data, which can be used to identify the racecar's position, and a transmitter, which transmits the positioning data to a central unit. This guarantees a cost-effective and reliable identification of vehicle position. In particular, the above precludes any confusion between racecars, because each racecar ascertains and transmits its own positioning data. The transmitter can also be used to transmit additional data to the central unit.

An advantageous embodiment of the invention as a positioning system entails a plurality of such vehicle-information devices in conjunction with a calculation device, which uses stored racetrack data to calculate the position of the respective racecars on a racetrack from transmitted positioning data. By using a virtual image of the racetrack in the form of racetrack data, the respective positions of the racecars can be identified using the transmitted positioning data, without requiring that position-identifying devices be set up at all major points of the racetrack. The location at which a vehicle leaves the racetrack or has stopped can also be precisely ascertained without additional expense.

The track data can be reused if professionally stored; with appropriate measures, they can also be updated, wholly or in part, when the track is modified. It is also possible to transmit the track data to another positioning system.

Individuals of skill in the art are familiar with the fact that positioning data can be gathered in the vehicle in a wide variety of ways. For example, the vehicle can be equipped with a GPS (global positioning system, a global, satellite-supported navigation system) receiver or another satellite receiver, a direction finder or a gyro sensor. A

redundant combination of such receivers or sensors can also be used. If desired, individual racecars can also be equipped with various positioning devices to obtain positioning data. In the use of direction finders, it is necessary to expand the positioning system with at least three direction-finding transmitters whose exact position on the racetrack is known. The position of the direction finder can be found by appropriately measuring the distance between the direction-finding transmitters and the respective direction finder.

As mentioned above, the transmitter provided in the vehicle-information device can be used to transmit vehicle-operating information, such as vehicle speed, engine RPM, or similar data. Such data are obtained using suitable sensors, or from the vehicle electronic system and can, for example, enable fast identification of stoppage or other danger situations for the racecar. In order to avoid misuse of the positioning and/or operating data, the data can be sent wholly or partially encrypted using known methods. Also relating to these preferred features of the invention, it is not necessary that the respective vehicle-information devices or racecars be equipped in the same way.

Preferably, the positioning system according to the invention comprises a central unit equipped with the aforementioned calculation device, a memory for storing racetrack data and one or more receivers for receiving the positioning and vehicle operating information transmitted by the respective vehicle-information devices. In these devices, the system components that do not have to be physically separate can be embodied as individual components, partial groups or as an integrated unit.

It is also advantageous if the central unit comprises a transmitter that can be used to transmit safety data, and one or more racecars participating in the positioning system have appropriate receivers and display devices to, if desired, receive and appropriately display the safety data. Thus, for example, if the positioning system according to the invention determined that a racecar had stopped, it could transmit a corresponding warning, analogous to the green, yellow and red flags used in Formula 1 racing, to signal the event to the other racecars participating in the positioning system.

In particular, the receivers installed in the racecars could also contain an identifying device, which would permit the control center to respond selectively to each receiver. In this way, it is possible to differentiate between the racecars participating in the positioning system based on danger status. For example, the vehicles that reach the danger zone after a long period of time could be signaled "green light," while the racecars that will soon pass the danger zone will be signaled "red light." All other racecars will be

signaled "yellow light." Other differentiation methods known to the industry, such as time-division multiplexing or frequency-division multiplexing, can also be used to permit selective response to the various racecars.

To circumvent the need for all racecars to participate in the positioning system and to insure greater track safety, the customary section monitors can also take part in the positioning system in that one or more of them is or are equipped with receivers and display devices that receive and appropriately display the transmitted safety data. Here as well, the use of an identifying device or the like can make it possible to selectively address each section monitor. For reasons of security, the safety information can be sent wholly or partially encrypted using known methods.

Preferably, the positioning system according to the invention includes a display device that permits a visual display of the current positions of selected racecars on the racecourse using the track data and the calculated vehicle positions. This task can, if desired, be performed by the calculation device so that no additional hardware is necessary for the display device. For example, the calculation device could convert the obtained position information with the track data into a video signal, which could be sent to the TV stations broadcasting the race. The display device can also comprise one or more large screens or video screens that present such visual displays of selected vehicle positions to the spectators at the racetrack. The result is a system which, in addition to its safety advantages, also has the special advantage of informing the spectators – regardless of where they are sitting -- about the latest race information pertaining the entire course in real time, thus substantially enhancing the appeal of attending a race.

Likewise, the display device can include a data-processing device which, among other things, can enable a visual display of the current positions of selected racecars on the track on visual data-processing devices, connected, for example, via a fixed network or radio link to the data-processing device for transmitting data. The above could, for example, be used to create a virtual broadcast of the race via the Internet. Other race

information collected by the positioning system according to the invention, for example, the current placement or the current speed of selected racecars, could be called up and viewed on such a data-processing device integrated into the positioning system with suitable linkage to the visual data-processing devices. In this way, the data-processing device is integrated into the positioning system in such a manner that the relevant race data contained in the positioning system can be converted and processed by an operator feeding them into a data network, and that a desired audio and/or video representation of the racing events and/or the desired race data is possible on the respective visual data-processing device. The respective displays of a plurality of visual data-processing devices can be different. For example, a mobile telephone acting as a visual data-processing device could be used to show the respective placement and lead of selected racecars, while a computer linked to the data-processing device via Internet could present a virtual depiction of the racing events, e.g., the current positions of any selected racecars on the track, on the screen. Preferably, the desired display type and/or the information to be displayed will be selected by interactive entry between the user of the visual data-processing device and the data-processing device.

According to the invention, all or selected components of the positioning system are preferably provided in redundant fashion to ensure the function of the positioning system even in the event of the failure of one or more components. This is especially true for safety components, for example the positioning system's calculation device.

Alternately, the positioning system according to the invention can be realized in the sense of a second embodiment, in which instead of the positioning device and the transmitter, the respective vehicle-information devices have only one transmitter for transmitting directional signals. Using at least three spatially separate direction finders included in the system, positioning data can be obtained outside the vehicle, where they can be processed by the calculation device as described above. Because, for example, the direction finder can be connected to the central unit by cable, if desired, there is no need

for a receiver in the central unit. All other features of the invention are the same as in the first embodiment.

It is also possible that this second embodiment will only be used on selected racecars, and/or the two embodiments of the inventions will coexist among race drivers.

The invention is described in greater detail below by way of an exemplary embodiment illustrated in the following drawings. Shown are in:

Fig. 1 a racetrack mapped out by track data according to a preferred embodiment of the invention;

Fig. 2A a racetrack with a positioning system according to a preferred embodiment of the invention, in the first embodiment;

Fig. 2B a racetrack with a positioning system according to a preferred embodiment of the invention, in the second embodiment;

Fig. 3A a racetrack with a vehicle-information device according to a preferred embodiment of the invention, in the first embodiment;

Fig. 3B a racetrack with a vehicle-information device according to a preferred embodiment of the invention in the second embodiment; and

Fig. 3C a racecar with a vehicle-information device according to a second embodiment.

In Figure 1, track data map out a racetrack 2 according to an advantageous embodiment of a positioning system 1 according to the invention. The figure shows a

plurality of racecars 3A, 3B, 3C and 3X on racetrack 2, participating in the positioning system.

To be able to calculate the position of one or more of racecars 3 on racetrack 2, racetrack 2 is stored by positioning system 1 in the form of visual track data in such a way that it is possible to compare the track data with the positioning data received from the respective racecars 3. This comparison is made in a calculation device 9, for example a digital EDP system of positioning system 1. Accordingly, the track data can be preferably stored in a professional way in a storage device of calculation device 1. It is also possible to store the track data in a storage device (10) linked to calculation device 9, or to store the track data on a memory storage unit which is accordingly read by a reading device in place of the storage device (10).

According to the embodiment shown in Figure 1, the racetrack 2 is represented by ordered sequences of corner points 11, which are measured in a fixed coordinate system 12 and function as track data. Connecting the corner points 11 one after the other by straight-line pieces thus defines an interior or exterior boundary of track 2. Using this method, it is possible to represent any two-dimensional track topology. Also, individual track sections and the preset travel direction can be defined using corner points 11 and/or the corner-point sequences. Of course, it is possible to use other methods for mapping tracks known to individuals of skill in the art.

In the embodiment shown in Figure 1, the positions of the racecars 3 are ascertained using the coordinate system 12. Because, however, comparing coordinate data from different coordinate systems requires only an arithmetical conversion, the positioning data of each racecar 3 can also be identified using other coordinate systems. This could be the case, for example, if some racecars were tracked by GPS receiver, while the positioning information of other racecars 3D was generated via direction-finding receivers participating in a locally installed direction-finding system 23.

The figure assumes and indicates that the racecars 3 move counterclockwise on racetrack 2. If it is also assumed that racecar 3X is stopped, racecar 3A is located near the danger site. Racecar 3B is still at a safe distance from the immediate danger zone, while according to the drawing, vehicle 3C is not in immediate danger. The fact that the position of racecar 3 essentially has not changed indicates that it has stopped. The individual degree of danger for the remaining cars 3A, 3B, 3C can be determined by ascertaining the affected track section and the respective positions of the remaining racecars 3A, 3B, 3C participating in positioning system 1.

Figures 2A and 2B show various features of a positioning system 1 according to an advantageous exemplary embodiment of the invention according to the first and second /embodiment of the invention. They show a racetrack 2 containing a number of racecars 3 participating in positioning system 1, as well as two GPS satellites 24. Positioned along the racetrack 2 are a number of section monitors 22, grandstands 20 and a video screen 21, with the first and last being components of the exemplary positioning system 1. In the figures, positioning system 1 also includes a central unit 7, a transmitter/receiver system 8 and a calculation device 9. In Figure 2B, positioning system 1 has three direction finders 23 instead of the GPS satellites.

In Figure 2A, according to the first embodiment of the invention, racecar 3D utilizes a GPS receiver as a positioning device 5, the receiver receiving radio signals from GPS satellites 24. From these signals, the GPS receiver or another suitable positioning device in the racecar 3 obtains positioning data, which can be used to determine the current position of racecar 3. A transmitter 6 in racecar 3 transmits the obtained positioning data to a central unit 7, which is equipped with a reception device 8 associated with transmitter 6. Accordingly, the respective transmitters 6 of racecars 3 and central unit 7 of the preferred embodiment shown in Figure 2A form a star network. Together, positioning

device 5 and transmitter 6 in racecar 3 form a vehicle-information device 4.

In Figure 2B, according to the second embodiment of the invention, the position of vehicle 3D is determined by a direction-finding transmitter 6B that is installed in vehicle 3D and has at least three direction-finding receivers 23 near racetrack 2, and by the calculation device 9 comprising central unit 7. The direction-finding transmitter 6B transmits direction-finding signals, which are received by the direction-finding transmitters, processed and routed as positioning data to central unit 7, where they are used in calculation device 9 to determine the position of vehicle 3D. The positioning data can be transmitted in a known manner, for example via cable, from the direction-finding receivers 23 to central unit 7. The foregoing could eliminate the need for a receiver 8 in central unit 7. In the illustrated embodiment, receiver 8 is used to receive vehicle operating information and/or redundant positioning data from a data transmitter 6A located in the vehicle, which is preferably used to check the position or the operating condition of racecar 3D.

According to the invention, each racecar 3 participating in positioning system 1 has a vehicle-information device 4. These devices can, however, be designed according to different operating principles. The steps described above to obtain positioning data and to calculate the position of a racecar 3 are likewise performed, *mutatis mutandis*, for the respective vehicles.

In a calculation device 9 assigned to central unit 7, which comprises a memory 10, the track data stored in 10 are used to calculate the position of racecar 3 on racetrack 2. The position calculated in this manner provides information regarding the placement of

racecar 3 among the racecars 3 participating in positioning system 1, and also about whether racecar 3 is stopped, has slowed down dangerously or has left racetrack 2.

Figures 2A and 2B show examples of a stopped vehicle 3X participating in the positioning system. Calculation device 9 uses the position information obtained therein to determine such a stopped state, or a corresponding device connected to calculation device 9, preferably located in the central unit 7, ascertains this fact. Subsequently, the

transmitter/receiver system 8 transmits an appropriate message to racecars 3 and/or to section monitors 22. For security reasons, transmitter/receiver system 8 preferably transmits the data according to the invention in encrypted form. Because the position of the stopped racecar 3X is known, it is possible, using an identifying device or another differentiator known to persons of skill in the art, to transmit a targeted message to the section monitor 22X closest to racecar 3X. It is accordingly possible to send a different message to racecar 3C than to racecars 3B or 3A. As mentioned above, in this way vehicle 3A could be signaled "red light" depending on the degree of danger, while racecar 3B could be signaled "yellow light," and the vehicles 3C "green light," which could be displayed in the respective vehicles 3. By the same token, the danger could be displayed on the track shoulder using appropriate display devices, for example by waving a flag or using a traffic light.

Figures 2A and 2B show a big screen video display 21, which makes possible a visual display of the current positions of selected racecars 3 on racetrack 2. The big screen video display 21 is supplied with signals generated in the calculation device 9 or in another display device using the positions calculated in calculation device 9 and the stored track data as described above. Such or similar signals can also be supplied to TV stations or to other communications services, for example to an Internet provider, to be broadcast. The display does not have to be limited to displaying vehicle positions; it can also include information regarding the respective vehicles 3 or other racing or advertising information.

The position information obtained by the positioning system 1 according to the invention relating to the participating racecars 3 can also be used to automatically direct or control television and surveillance cameras to one or more vehicles 3 along track 2. Also, the image captured by the camera that has the best view of a selected racecar 3 can be displayed automatically. A person of skill in the art can easily recognize several other, equally applicable variations of this principle.

The vehicles taking part in the race require minimal outfitting or refitting. Figures 3A, 3B and 3C show different embodiments of the two versions of a racecar 3 equipped according to the invention. According to the invention, the vehicles 3 are equipped with an antenna 30 and a vehicle-information device 4, which are installed professionally in or on the vehicle. The latter are indicated by dotted lines in Figure 3B.

Figure 3A shows a racecar with a minimally equipped vehicle-information device 4 according to the first embodiment of the invention, whereby vehicle-information device 4 comprises only the essential components. Accordingly, vehicle-information device 4 comprises only a positioning device 5 and a transmitter 6.

In the illustrated embodiment, a GPS receiver functions as a positioning device 5 and a data transmitter 6A fulfils the role of the transmitter 6. Using the antenna 30, GPS radio signals are transmitted from a GPS satellite 24 to the GPS receiver, where they are processed into positioning data. The positioning data are converted accordingly in data transmitter 6A and supplied to antenna 30, from which they are sent to a receiver 8 in central unit 7. It is known to a person of skill in the art that it is possible, if desired, to distribute the tasks among the components 5, 6 comprising vehicle-information device 4 in a different way. As mentioned above, other positioning devices 5 and transmitters 6 can also be used according to the invention.

Figure 3B shows a racecar with a minimally equipped vehicle-information device 4 according to the second embodiment of the invention, whereby the vehicle-information device 4 comprises only the essential components. Accordingly, the vehicle-information device 4 consists of only one direction-finding transmitter 6B, which transmits direction-finding signals via antenna 30 to corresponding direction-finding receivers 23, from where they are processed as described above.

According to the invention, the respective vehicle-information devices 4 of the vehicles 3 participating in the positioning system can be additionally connected to one or

more devices 33 – 39, or even include them; these devices transmit vehicle operating data or redundant positioning data directly, or via vehicle-information device 4, to transmitter 6 for transmitting these vehicle operating data and/or positioning data to central unit 7. A vehicle 3 equipped with many different accessory devices is shown in Figure 3C. According to the invention, these additional devices 33 – 39 can vary among the respective vehicles 3. The type of additional equipment of each vehicle 3 depends, among other things, on the weight of the devices 33 – 39 and their cost and space requirements.

The racecar 3 of the embodiment shown in Figure 3C corresponds to both the first and the second embodiments of the invention, because the illustrated vehicle-information device 4 is equipped with both a direction-finding transmitter 6 and a positioning device 5 and a transmitter 6. As a result, it is possible to redundantly track the vehicle using the positioning system according to the invention.

The shown vehicle-information device 4 optionally uses a GPS receiver as positioning device 5. Using antenna 30 or a separate antenna, GPS receiver 5 receives GPS signals 40 from GPS satellites 23, from which it obtains GPS positioning data that are then routed to data transmitter 6 to be transmitted to central unit 7. Although the thus obtained GPS data are known to be faulty, according to the invention no correction is absolutely required, because the error equally affects all vehicles 3 participating in the positioning system. If desired, a GPS receiver can be installed in central unit 7, whose GPS data will be compared with the fixed, known position of central unit 7 to generate a correction vector for the GPS information from the vehicles 3.

For redundant positioning of racecar 3, the illustrated vehicle-information device 4 also contains a direction-finding transmitter 6, which transmits direction signals to the direction-finding receivers 23 set up near racetrack 2 via antenna 30 or a separate antenna. As described above, that is where positioning data are obtained from the direction signals to be used in central unit 7. If desired, data transmitter 6 assumes the

function of direction-finding transmitter 6, or the two transmitters 6 are produced as an integral unit.

The shown racecar 3 comprises as additional equipment a tachometer 33, a gear-train sensor 34, a ground-motion sensor 35, a gyro sensor 38, an induction-loop sensor 37, a wheel-rotation sensor 38, and a position receiver 39. The gyro sensor 36 measures the acceleration of vehicle 3 using a piezoelectric component installed in the gyro sensor 36, and supplies positioning data based on acceleration measurements. The tachometer 33 and the wheel-rotation sensor 38 measure, using conventional methods, the rotation speed of the engine and the wheels and supply corresponding data, preferably in the form of pulse information or other digital data. The ground-motion sensor 35 uses infrared, ultrasound, or radar signals to determine the speed of vehicle 3 and to transmit this information in an appropriate data format. Gear-train sensor 34 determines the speed of the driving motor at the gears and transmits this information in data format. When the vehicle drives past induction loops embedded in the track in a conventional way, this can be read by the induction loop sensor 37 to obtain positioning information. Small-aperture position transmitters can also be placed along the track, which emit positioning signals 49 over a specific area. The positioning signals 49 are received by the position receiver 39 via antenna 30 or a separate antenna, which converts the positioning signals 49 into positioning data and to data transmitter 6, which routes them on to central unit 7.

According to the illustrated embodiment, the data from the respective sensors or devices 33 – 38 are routed as data signals 43 – 48 to data transmitter 6 to be routed to central unit 7. As indicated in Figure 3C, selected portions of the data signals 43 – 48 are, if desired, not routed to data transmitter 6 until they have been converted in vehicle information device 4. For security reasons, transmitter 6 preferably transmits the data according to the invention in encrypted form.

The illustrated vehicle-information device 4 also comprises a data receiver 31, which receives safety and/or data signals 42 via antenna 30 or a separate antenna, preferably

from central unit 7. The signals 42 are accordingly converted in data receiver 31 or in vehicle-information device 4 to generate, as discussed above, warning or other messages via a display device, for example, in the form of a cockpit display light 32 on the dashboard 32.

According to the invention, the various components of vehicle-information device 4, and sensors 33 – 38 are mounted to a suitable place on board vehicle 3, and appropriately connected or networked with each other via transmitter 6 to obtain the desired functioning capability. A person of skill in the art is aware that the described distribution of functions can, if desired, be structured differently among the components encompassed by the positioning system according to the invention.

In addition to determining RPM, acceleration values, direction of revolution, and speed of movement, the data obtained by the physical sensors 33 – 38 can also be compared to verify whether the obtained values interact correctly for proper locomotion of vehicle 3. For example, if the drive train rotates at an unusually higher rate than the wheel RPM, this can be diagnosed immediately as a differential defect, or, if the wheels revolve unusually faster than the recorded locomotion speed over the ground, this can be immediately diagnosed as wheel slippage. Together with the results of acceleration sensor 36 and, optionally, GPS receiver 5, the above can be used to verify a deviation from the allowable motion parameters, not only with absolute values, but also using redundant supplemental information.

The data obtained by the GPS positioning device 5 and the physical sensors can be used to test the correct or faulty motion of vehicle 3 on racetrack 2 in the direction of travel with a high degree of certainty. The data obtained by the described sensors and devices or similar ones can be used in central unit 7 to ascertain possible motor failure, the position, speed, or similar characteristic data of a racecar participating in the positioning system.

A person of skill in the art can use a limitless number of devices to obtain, process, transmit and/or evaluate the positioning and operating data participating in the present invention. For example, the data of the different racecars 3 can be distinguished by using a frequency-division or time-division multiplex signal or a suitable identifying device for the transmitted data.

Therefore, the embodiments and applications of the invention explained in the description serve merely as examples of what an individual of skill in the art understands or could understand in each context as being equivalent, and which, if desired, could be used instead of one of the listed examples. Such equivalents are therefore as much a part of the invention as the explicitly described, incomplete examples.